Is the Phone Mightier than the Sword?
Cell Phones and Insurgent Violence in Iraq[1]

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Abstract

Does improved communication as provided by modern cell phone technology affect the production of violence during insurgencies? Theoretical predictions are ambiguous, introducing cell phones can enhance insurgent communications but can also make it easier for the population to share information with counterinsurgents and creates passive signals intelligence collection opportunities. We provide the first systematic test of the effect of cell phone communication on conflict using data on Iraq's cell phone network and event data on violence. We show that increased mobile communications reduced insurgent violence in Iraq, both at the district level and for specific local coverage areas.

Keywords: Insurgency, Political Violence, Information Communication Technology

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INTRODUCTION

In 2007, cell phone subscriptions reached 3.3 billion worldwide, which corresponds to half the world's population (Virki 2007). The increase in wireless communication has been one of the most important technological advances of the last two decades, with tremendous economic and social consequences. There are plenty of reasons to be enthusiastic about this progress. Economists, for example, have shown that improved mobile communications can enhance market performance in Indian fishing communities (Jensen 2011) and reduce price dispersion in grain markets in Niger (Aker 2008). At the same time, however, there are circumstances under which cell phone communication can have more pernicious effects. Governments are increasingly afraid of the potential for collective mobilization that is introduced by modern communication technology. During the recent protests in Egypt, the Mubarak government shut down all cell phone communications in an attempt to stop the large crowd of protesters from growing further (Richtel 2011). Similarly, Mozambique's government attempted to shut down text message traffic during swelling protests over food prices in Fall 2010 (BBC 2010). Analysts of organized crime, terrorism, and insurgency have long argued that the spread of cheap and reliable mobile communications will open up a range of new organizational models for terrorists and rebels (see e.g. Arquilla, Ronfeldt, and Zanini 1999; Andreas 2002).

If cell phone communication is conducive to subversive action, insurgents should be among the keenest adopters of this technology. Indeed, anecdotal evidence from Iraq suggests this, with press reports labeling cell phones an "explosive tool for insurgents" (Washington Times 2005) and some arguing that mobile communications enabled a "networked insurgency" in Iraq (Muckian 2006). That cell phones can be key infrastructure for insurgent communication is corroborated by the observation that while insurgents in Iraq frequently attacked water and electricity networks, they carefully spared the cell phone network (Brand 2007) even threatened telecommunication companies for not doing enough to maintain their network (Blakely 2005). This pattern from Iraq, however, contrasts with anecdotes from Afghanistan, where the Taliban insurgents seem afraid of cell phone technology. They have issued decrees ordering all cell phone towers to be turned off during nightly hours, in an attempt to prevent villagers from calling in tips to the military forces (Trofimov 2010) and have attacked and destroyed cell phone towers for the same purpose (Shachtman 2008).

As the above examples show, it is not obvious whether or how the availability of cellular communications influences political violence. Governments facing insurgencies in Colombia, India, Pakistan, the Philippines and elsewhere must balance the well-documented economic advantages of expanding mobile phone coverage with the possibility that such coverage will make it harder to establish stability. A number of countries including Bangladesh, Pakistan, and the Philippines have recently considered tighter restrictions on cell phone registration because of their utility to violent groups. Thailand introduced new identification standards for mobile phones in 2005 exactly because of the phones' perceived utility for separatist insurgents in southern Thailand. Such measures inevitably reduce cell phone penetration on the margins and so the belief that greater cellular use is a net benefit to terrorists and insurgents may have lasting negative economic externalities.

Existing theories about the industrial organization of violence are little help in sorting out possible impacts as none explicitly deal with the ease of communication. As we mentioned above, cell phones make collective action easier. Equipped with light, mobile communication devices, insurgents can easily coordinate actions, execute attacks and quickly react to counterinsurgency operations (see e.g. Cordesman 2005, Leahy 2005, Strother 2007). Following this line of reasoning, increased cell phone availability should lead to higher levels of violence. At the same time, however, cell phone availability could benefit counterinsurgents. In general, cell phones make it easier for the population to share information about insurgent activity, and to safely and anonymously call in tips. If this were true, and if the provision of information to counterinsurgents by the population were generally the binding constraint on the production of violence (Berman, Shapiro, and Felter 2011), then greater cell phone availability would lead to less violence. Insurgent use of cell phones, moreover, may create operational vulnerabilities given many governments' abilities to monitor them. It was cell phone monitoring, in part, that helped U.S. forces kill several senior al-Qa'ida in Iraq leaders including Abu Musab al-Zarqawi (Perry et al. 2006) and that reportedly played a key role in leading the U.S. to Osama bin Laden.

We make the first systematic attempt to examine whether cellular communications networks are security enhancing or not. Using detailed data on cell phone networks and violence in Iraq, we estimate the effect of cell phone network expansion on insurgent violence at two levels. First, because the insurgency was organized regionally, we conduct a district-level analysis, assessing whether increased coverage at the district level is associated with changes in violence. We find that better coverage at the district level leads to a clear and robust decrease in insurgent attacks for most of the war. In Sunni and mixed ethnicity districts of Iraq, where the vast majority of the violence took place, a one standard deviation increase in the number of towers in a district (1.9 towers) leads to 3.9 fewer attacks in the next month, a 12.3% reduction from the mean number of attacks per month. This suggests that the information-enhancing effects of improved cellular coverage swamp its effects on insurgents' ability to organize. Second, in order to provide evidence on the mechanisms behind the main district-level effects, we study the local effect of cell phone towers within specific coverage areas. Using a novel spatial-temporal difference-in-difference design, we show that after a tower is turned on, the number of improvised explosive device attacks is significantly lower for at least 16 weeks in the area around towers that introduce substantial new coverage (both statistically and substantively) but not around towers that merely increase existing capacity. This finding is especially striking as cellular coverage opens up a broad range of technologies for fusing IEDs.

The remainder of the paper proceeds as follows. Section 1 outlines the core theoretical ambiguity motivating the paper. Section 2 provides background on the history of the Iraqi cellular communications network and outlines the empirical strategy that flows from this history. Section 3 describes our data in detail and provides core descriptive statistics. Section 4 provides the results, first at the regional level and then for specific local coverage areas. Section 5 concludes by discussing the relevance of our findings for studies of the impact of technology on society and for studies of political violence and insurgency.

1. Cell Phones and Insurgent Violence

Theories of insurgent violence and collective action provide conflicting predictions about the impact of introducing cellular communications into areas with ongoing violence. Cellular communication technology could lead to increasing violence to the extent that introducing cell phones made it easier for insurgents to coordinate attacks, mass forces, operate in a coordinated fashion without a defined chain of command, and the like. We know, for example, that governments routinely shut down cellular communications to fight mass political behaviors (see e.g. the recent unrest in Egypt).

There is ample evidence that some players in the Iraqi insurgency felt that cell phone networks were a boon to insurgents. In the first place, cell phone service opened up a range of fusing options for improvised explosive devices (IEDs). With cellular coverage insurgents could call phones to detonate bombs, they could set up bombs that would detonate when Coalition jammers terminated a call, and they could communicate between spotters and those controlling an explosive, meaning that the controller no longer needed to be within line-of-sight of the IED. Appendix Figure A1 shows a cell-phone triggered IED. Given the manifest potential military advantages to insurgents of having cell phones, it is perhaps not to surprising that in 2005 the chairman of the Iraqi National Communications and Media Commission reported companies were being "threatened by terrorists for delays in setting up masts" because "Terrorists like mobile companies." (Blakely 2005).

Yet there are also strong reasons to think the expansion of cellular communications could have aided Coalition intelligence gathering efforts. First, the better coverage is, the more insurgent might use cell phones, and one thing the Coalition was very good at was exploiting wireless communications. Second, shortly after the invasion in 2003, the National Tips Hot Line was rolled out by the Coalition Provisional Authority with nearly $10 million budgeted for billboard, print, radio, and television advertising (Semple 2006). Throughout Baghdad in 2004, the tip line was advertised as a way to "fight the war in secret" (Miles 2004). Soldiers in many areas carried cards advertising tip lines, such as the one in Appendix Figure A2 that was distributed by soldiers of the U.S. Army 3rd Infantry Division operating in al-Zubayr, near Basrah, in 2010. Indeed, in Afghanistan insurgents have long targeted cell towers exactly because cellular communications make it easier for the population to inform on them (see e.g. Trofimov 2010).

Both simple decision theoretic and fully strategic models yield the same basic ambiguity about how altering the ease of communication influences the level of violence. In a decision theoretic framework, if enhanced communications makes it easier to produce violence and enhances the information counterinsurgents have, then their net effect is ambiguous.[2] Many fully strategic models yield the same basic ambiguity about how expanded cellular coverage should impact violence in equilibrium. In the model in Berman, Shapiro, and Felter (2011), for example, increased coverage could reduce rebels' capacity to retaliate against those who share information but it could also reduce rebels' costs of producing violence. Those changes have opposite effects on equilibrium levels of violence. Given that deep theoretical ambiguity we focus in what follows on identifying the direction of the net reduced-form relationship in Iraq.

In doing so, we have a limited ability to provide evidence on which of the competing mechanisms are in play. We cannot directly assess the impact of expanded cellular communications on information flow to counterinsurgents, for example, because no unclassified data exist on such information transfers. Intelligence from human sources (HUMINT) is among the most highly-classified types of information held by the U.S. military and no unclassified data on tips provided to Coalition forces in Iraq exist. On the insurgent side, there is an extensive collection of captured documents from Iraq that can be used to assess the efficiency of various insurgent organizations at specific points in time and space. Bahney et. al. (2011), for example, study how costly it was for one insurgent group (al-Qa'ida in Iraq) to produce attacks. Unfortunately, the vast majority of these captured documents remain in the classified Harmony database and so constructing panel data from them is not currently possible. Instead, as is often the case, the best we can do is to make the cautious case about how our results are consistent (or not) with different mechanisms.

2. BACKGROUND AND IDENTIFICATION STRATEGY

2.1 THE BUILDUP OF IRAQ'S CELL PHONE NETWORK

Whereas under the regime of Saddam Hussein mobile communication was only accessible to a small minority of Iraqis, the network has seen a rapid expansion in the recent years. Less than 10% of

[2] For an illustration of how this works with a Cobb-Douglas production function for violence see online Appendix A.

Iraq's population of approximately 25 million people lived in areas with cell phone coverage at the beginning of 2004.[3] By February 2009, when our data on violence end, Zain alone reported over 10 million subscribers. Figure 1 shows the spatial-temporal evolution of the network over the course of the study period.[4] Existing towers in the respective year are shown in black, towers introduced during the course of the year in red, and future towers in grey. The histograms below each panel show the numbers of towers introduced per month.

[INSERT FIGURE 1 ABOUT HERE.]

These maps show exactly what one would expect given the fact that after coalition forces had invaded Iraq and toppled Saddam in 2003, the establishment of modern communication networks was a priority during the reconstruction efforts. In late 2003, the Iraqi government sold contracts to establish cell phone networks to three companies, one for each of three regions (northern, southern and central Iraq). Asiacell won the contract for the northern region. Iraqna, then part of the Egypt-based Orascom group, provided services in the central region including Baghdad. The contract for the southern region went to MTC Atheer, part of the MTC Corporation that operates in various countries in the Middle East and Africa.

The fragmented structure of the cell phone network led to various inconveniences for service users. Frequently, because of the necessity to communicate from different regions, people were required to carry multiple phones, each for one of the providers.[5] In order to improve existing coverage and enable nation-wide competition, the government auctioned three licenses for national coverage in fall 2007. Two of these licenses were awarded to operators based primarily in northern Iraq (Asiacell and Korektel), and MTC Atheer won the third. Iraqna did not bid, because it considered the costs of the license to be too high. Shortly after, the MTC group announced its decision to buy Iraqna and merge it with its existing Iraqi company, MTC Atheer, creating the largest cell phone provider in Iraq. In January 2008, the MTC group changed its name to Zain. Even though other providers are expanding heavily in Iraq's central and southern regions, Zain Iraq is the

[3] Authors' calculations based on coverage areas and Landscan population data.
[4] Appendix figure A3 shows the number of Iraqis living in areas covered by Zain Iraq's network from 2004 through 2009.
[5] USA TODAY, March 23, 2006, http://www.usatoday.com/news/world/iraq/2006-03-23-cellphones-iraq_x.htm

largest provider in Iraq, with an estimated number of 10.3 Million customers at the end of 2009.[6] During most of the period under study, companies that are now part of Zain provided all the coverage in Southern and Central Iraq where the vast majority of the civil war violence took place.

2.2 LOCAL EXPANSION OF THE NETWORK

Since our analysis exploits the expansion of the network in Iraq to assess cellular communications' effects on violence, a close look at the micro-dynamics of network expansion is necessary and provides crucial background for our identification strategy. The following description is based on extended conversations with MEC Gulf, a consulting firm that advises cell phone companies on network expansion, as well as the chief technology officers for Zain Iraq and Asiacell, two of the three major telecommunications providers in Iraq. It represents a consensus view, though details varied across firms, over time, and between projects.

Development of the cellular communications network in Iraq was based on a phased approach in which firms first selected larger areas for expansion, and then chose specific sites for cell phone towers within these areas based on the practicalities of providing coverage at minimum cost. For both Zain and Asiacell, areas for expansion were selected on an annual basis (towards the end of each company's fiscal year) based on three core criteria: requirements to meet service standards in existing areas as usage picked up; demand for cell phone service (large population without service); and contiguity with pre-existing coverage areas. An area chosen for expansion would typically be a large town, such as Fallujah, which first received coverage in 2004, or a semi-rural area with a large number of small communities.

Once these larger areas were selected, the radio-frequency (RF) design teams would map out a coverage plan that met a number of criteria including minimizing the number of towers while maximizing coverage and backhaul capacity. Two factors made their task more challenging in Iraq. First, the network backhaul in Iraq—the transmission of signals from the tower to a switch and then back out to the appropriate tower—occurred mostly via microwave as the country had no fiber optic network. Towers were therefore placed more closely together than in other settings to avoid

[6] Zain Iraq website, http://www.zain.com/muse/obj/portal.view/content/About%20us/Worldwide%20Presence/Iraq

interference from the microwave signals between towers.[7] Second, the pervasive use of jammers in Iraq by both Coalition forces and civilians meant that the providers needed to broadcast a stronger signal to guarantee coverage inside buildings than would be the case in normal urban settings.

Taking these constraints into account, the RF design teams would identify search rings of approximately one block radius in a number of locations within the targeted areas. Within these rings, a site selection team would then identify two or three potential sites that were suitable for tower installation. These would typically be buildings that had a relatively unobstructed view, but at the same time could support the weight of a cell phone antenna and the supporting equipment (generator). Once a list of candidate buildings had been put together, the respective proprietor of the building or the landowner would be contacted regarding a possible lease by the site acquisition team. If a search ring were deemed to be in an inaccessible area, then the RF design team would typically need to identify new search rings for multiple towers, not just the one initially sited in an inaccessible area. Typically, it would take two to three months for the market research process of identifying target expansion areas, about a month for the RF design, and then another two to three months from the establishment of the initial search rings to the completion of the final site list with sites secured, leased and ready to build. The setup of towers themselves would take anything from a couple of days (for rooftop sites) to a few weeks (for ground towers in more rural areas).

2.3 Identification Strategy

We want to identify the impact of cell phones on violence in Iraq at two levels: at the district level and for specific local coverage areas. Each requires a slightly different approach.

District-Level Empirical Approach

At the district level we employ the standard panel data approach of using a range of controls to account for factors influencing the expansion of the network. We might, for example, be concerned that expansion of the network is correlated with economic activity, which appears to be positively correlated with insurgent violence in Iraq (Berman, Callen, Felter, and Shapiro 2011). Our

[7] The microwave signals between towers are highly directional. If towers were placed too far apart, there would be interference in those signals between towers as the beam from one tower to the other would spread beyond the width of the receiving antenna.

panel data approach is justified to the extent that we believe controlling for factors such as the number of pre-existing towers in a district and time and space fixed effects will account for the core drivers of network expansion. So how viable is this approach?

Given what we know about how the network was built, it is extremely unlikely that month-to-month variation in violence impacted the networks construction. In numerous conversations with those who built the network we heard no reports of major design changes being made in response to existing or anticipated insurgent violence. The site acquisition teams reportedly employed various strategies to push expansion even in the context of difficult security situations such as Fallujah in 2004 and Ramadi in 2006. The teams would typically enter into long-term contracts with local community members and organizations to pay for site rental, generator fueling, site security, and training of local engineers to provide these services. Where possible, they would engage with local elites to identify the personnel who could be entrusted with these jobs. This strategy of establishing close connection to local elites meant that once marketing had identified an area for network expansion, teams were able to move in effectively even in areas with high violence.

Many factors orthogonal to violence clearly did influence tower construction, often in ways that lead us to believe the month-to-month timing had a large random component. Towers were delayed due to unpredictable decisions by government officials, difficulties in identifying whether a potential lessor actually held title to the land that was supposed to be leased for a tower, and disputes that arose once a site had been selected as the value of the lease and servicing contracts drew interested parties to make claims to land. Given these risks, the major firms often employed what was described as a "scatter-shot" approach to mitigate the risks from insecure titles. The idea was that as soon as the site-selection was done they would try to secure title to all of the sites in their expansion plan at the same time, as opposed to securing them in the order marketing suggested. As a practical matter, this meant they often built out in a different order than the marketing or service provision priorities alone would have dictated.

The variability in the rate of new tower construction is highlighted in Figure 3 which plots the monthly time-series of violence per capita in the blue series (left-hand axis) and the number of towers introduced in the red series (right-hand axis) for 20 select districts of Iraq. Two patterns are apparent here. First, there is tremendous month-to-month variation in the rate of new tower introduction, both within periods of high violence and during periods of peace. Second, there appears to be some correlation between extremely high violence and low tower introduction (Al-Muqdadiyah in Baghdad in 2007 for example) in a few places.

[INSERT FIGURE 3 ABOUT HERE.]

That apparently weak correlation at the district level aggregates up to an obvious relationship at the national level. As Appendix Figure A3 highlights, the rate of tower construction dropped dramatically during the peak of the civil war, from August 2006 to July 2007. It is not obvious however, how the national level drop in tower construction would bias the results. If towers are being built right up to the period when violence starts, for example, then lagged tower introductions should correlate positively with current levels of insurgent violence, the opposite is the case. What is clear from the patterns in Figures 3 and A3 is that adequately controlling for secular trends is going to be key to estimating the effect of towers on violence.

To conduct a more direct test of the possibility that tower construction was influenced by violence trends, we plot the average date of tower introduction within a district in a given year on the levels of violence in: (a) the last six months of violence in the previous year and (b) the first six months of violence in a given year. If tower construction is delayed by levels of violence at the end of the previous year, which would have made it harder to adjudicate titles, that would lead to a positive slope as the average date of introduction was pushed back. If towers were being introduced in ways that avoided violent districts, we should see a positive slope for the second plot as tower construction teams avoid highly violent places and so delay construction.

Neither was the case. Figure 4 shows that there is no consistent pattern across years at the district level. The top panel shows the relationship between levels of violence in the last six months of a year (plotted on the y-axis) and the average date of tower introduction in the next year (plotted on the x-axis). The bottom panel shows the relationship across years between levels of violence in the first six months of a year (plotted on the y-axis) and the mean date of tower introduction (plotted on the bottom panel). Only one of the bivariate correlations shown in the figure is statistically significant at the 95% level (the relationship between average date of tower introduction and violence in the direst six months of the current year, and that one is in the opposite of the expected direction. All these correlations become substantively small and statistically insignificant when the years are pooled or when sect fixed-effects are added to account for the average differences between purely Sunni regions where the nationalist insurgency dominated, and mixed regions which faced both a nationalist insurgency and a sectarian civil war.[8]

[INSERT FIGURE 4 ABOUT HERE.]

Our core specification at the district level is therefore a basic first-differences approach in which we identify the within-district variation in tower introductions and violence as follows:

$$\text{(3)} \qquad \nu_{i,t+1} - \nu_{i,t} = \alpha + \beta_1(\text{towers}_{i,t} - \text{towers}_{i,t-1}) + f_i + \delta_t + \epsilon_{i,t} \,,$$

where f_i is a district fixed-effect and δ_t is a time-fixed effect. We lag the difference in tower construction by one month to prevent simultaneity bias. In the results section, we will rely on (a) the robustness of the core results to the inclusion of a broad range of time fixed-effects and (b) the fact that the core results pass both geographic and temporal placebo tests to provide confidence that the results are not driven by selection based on anticipated violence.

Appendix Table A2 provides descriptive statistics at the district/month level. The data cover all 63 districts in which Zain had towers for the 60 months between February 2004 and February 2009, the period for which we have data on attacks. While the average district of Iraq was quite violent during this period, experiencing 43 attacks per month, the distribution is actually quite uneven as Figure 3 dramatically illustrates. Some districts experience very little violence on both a per capita and absolute basis, while others were quite violent in both senses. Importantly, even the most violent districts had substantial infrastructure put in during the period under study. Tower were introduced at a rate of 1 every two months in the average district, though the rate was much higher in the larger, more densely populated areas such as the districts in Baghdad governorate.

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[8] Results of regressions pooling across years and adding controls to account for differences between them are in Appendix Table A1.

3. DATA

3.1 CELL PHONE COVERAGE

Data on the coverage of the cell phone network was made available to us by *Zain Iraq* and covers the period 2004-2009. As described above, Zain purchased the other provider operating in central and southern Iraq, Iraqna, in 2007 and so our data include the vast majority of towers operating in areas of Iraq experiencing violence between 2004 and 2008. The original dataset records information on 7,687 cellphone antennas with their precise onair date and geographic location. Antennas were installed in groups of two or three per cell phone tower, so that together they provided a roughly 360° coverage around the tower. From the original dataset we derived a tower dataset of 2,489 unique locations. Due to missing onair dates, 73 of these towers were dropped, which leaves us with 2,416 towers included in the analysis.

For our tower-level analysis described in detail below, we require approximations of the towers' coverage areas. We approximate the coverage of individual towers by a circular area. Depending on whether a tower is located in an urban or rural area, we assign a short radius or a long radius. In conversations with electrical engineers we determined radii of 4 km and 12 km to be good first-order approximations of the coverage areas given the equipment used on the towers, but we also conduct robustness checks with alternative ones. In ongoing work we are estimating more precise coverage areas by exploiting information on other factors including the azimuth of antennas on the towers, the microwave backhaul requirements of the network, and the changing requirements for coverage over time as Zain built out in densely-populated areas. This analysis entails substantial complications and so for purposes of this paper we restrict ourselves to approximating coverage.

3.2 ATTACKS

Our measure of attacks against Coalition and Iraqi government forces is based on 193,264 'significant activity' (SIGACT) reports by Coalition forces that capture a wide variety of information about "…executed enemy attacks targeted against coalition, Iraqi Security Forces (ISF), civilians, Iraqi infrastructure and government organizations" occurring between 4 February 2004 and 24 February 2009. Unclassified data drawn from the MNF-I SIGACTS III Database were provided to the Empirical Studies of Conflict (ESOC) project in 2008 and 2009. These data provide the location, date, time, and type of attack incidents but do not include any information pertaining to the Coalition Force units involved, Coalition Force casualties or battle damage incurred. Moreover, they exclude coalition-initiated events where no one returned fire, such as indirect fire attacks not triggered by initiating insurgent attacks or targeted raids that go well. We filter the data to remove attacks we can positively identify as being directed at civilians or other insurgent groups, leaving us with a sample of 168,730 attack incidents.[9] Figure 3 highlighted the great variation in the patterns of violence over time across the 30 most violent districts in our sample.

3.3 Civilian Population and Ethnicity

To estimate the population we employ the fine-grained population data from LandScan (2008), a population raster dataset whose cell-based estimates were aggregated up to the district level.[10] Estimates of a district's ethnic composition were obtained by combining these data with precise ethnic maps of Iraq. After collecting every map we could find of Iraq's ethnic mix, we geo-referenced them and combined them with the population data to generate estimates of the proportion of each district's population that fell into each of the three main groups (Sunni, Shia, Kurd).[11] Using the figures from what we judged to be the most reliable map (a CIA map from 2003), we coded districts as mixed if no ethnic group had more than 66% of the population, otherwise the district was coded as belonging to its dominant ethnic group.[12] There were large population movements during the war, but the sectarian changes were concentrated in Baghdad and there they occurred mostly neighborhood-to-neighborhood, at smaller geographic units than we are using.

4. Results

This section analyzes the impact of expanding the cell phone network on violence at two levels. First, we analyze regional effects using standard panel data techniques and report a number of

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[9] We thank Lee Ewing for suggesting the filters we applied.

[10] The LandScan data provide worldwide population estimates for every cell of a 30" X 30" latitude/longitude grid (approx. 800m on a side). Population counts are apportioned to each grid cell based on an algorithm which takes into account proximity to roads, slope, land cover, nighttime illumination, and other information. Full details on the data are available at http://www.ornl.gov/sci/landscan/.

[11] Thanks to Josh Borkowski and Zeynep Bulutgil for conducting the coding. Full codebook and replication files are available on request.

[12] For a discussion of alternative methods for calculating ethnic shares see Condra and Shapiro (2011).

robustness checks. Second, we show how the regional effects of expanded coverage vary by type of attack and by sectarian area, providing evidence as to the mechanisms at play. Finally, we analyze the effect of introducing coverage over specific local areas using a novel approach that looks for changes in violence when towers are first turned on and then uses towers turned on in areas with pre-existing coverage to provide a placebo which allows us to rule out all but most unlikely sources of omitted variable bias. This approach correctly identifies the impact of introducing coverage so long as any omitted variables influencing tower introduction are similar in locations that provide new coverage and in ones that simply improve existing capacity.

4.1 Regional Impact of Cell Phones: District-Month Results

At the district level, we find that adding additional cell phone coverage decreases violence. In column (3) of Table 1 we present results from a simple model regressing total attacks in period t on the number of towers built in t-1, the number of pre-existing towers in a district, the proportions of the district that are Sunni and Shia, and province and half-year fixed effects to pick up the large secular trends in violence. In this basic specification, the introduction of one new tower correlates with approximately 2.8 fewer attacks in that month in an average sized Iraqi district.[13] This effect is not large, the average district in our data sees 36 attacks per month, but it is strongly significant using robust standard errors clustered at the district level.

[INSERT TABLE 1 ABOUT HERE.]

Columns (4) – (10) present the core specification in first differences that nets out district-specific factors such as the anticipated long-term economic value of the district, which might impact trends in both insurgent violence and the introduction of cell phones. The results in differences are smaller but remain statistically significant once we control for national changes using time fixed-effects for the quarter-year (column 5) or month (column 6). Adding a district fixed-effect in addition to differencing (column 7) shows the results are robust to controlling for time-invariant district effects in addition to district-specific trends. Allowing the fixed effects to vary across the intersections of time and ethnic regions in columns (8 to 9) accounts for the fact that trends in the

[13] The average district in Zain's coverage area has 327,000 residents, so 3.27*-.857 = -2.8.

war were quite heterogeneous across different regions. The peak violence in Anbar province where Sunni tribes were fighting a nationalist insurgency, for example, came six months before violence peaked in Baghdad where Sunni and Shia militias were engaged in a sectarian conflict. The result remain substantively similar and statistically strong even when we include a district fixed effect and net out the average violence in the each of the 13 provinces each quarter (column 10), an extremely robust way to control for the geographically-specific trends in the conflict and in incentives to build towers. Appendix Tables A3 shows the results of the most stringent specifications (columns 7 and 10) are robust to the inclusion of the spatial lag of violence as an additional control.

Overall, the introduction of new towers correlates with less violence no matter how we handle secular trends in violence. In the most stringent model, column (10), a one standard deviation increase in the number of towers in a district (1.8) predicts 1.1 less attacks (-.188 * 3.27 * 1.8) in the following month, a 10% decrease from the mean level of violence.

Before proceeding it is worth assessing whether the results might be driven by: (1) omitted variables driving trends in both violence and tower construction; (2) the direct impact of violence on future tower construction; or (3) enhanced coverage making insurgents more effective, allowing them to conduct more lethal attacks (e.g. shifting from a large number of small ambushes to a small number of large complex attacks). To check for the first possibility we use temporal and geographic placebo tests. Appendix Table A4 places the number of new towers introduced in the next month on the RHS (the lead difference) and Appendix Table A5 places the number of towers introduced in neighboring districts on the RHS (the spatial lag of the lagged difference). None of the coefficients are significant in the differenced specifications, providing additional confidence that the combination of differencing and fixed effects in Table 1 properly identify the impact of tower construction at the district-month level.

While we argued the second possibility is unlikely given that the cell phone providers reported insurgent violence did not interfere with tower construction, violence might impact tower construction in less direct ways. The providers reported that the main source of month-to-month delays in tower construction arose from the need to secure clear title to properties before building.

Past sectarian violence, which is weakly correlated with insurgent attacks ($\rho = .203$), clearly drove population movements which likely made it harder to secure clear title to desired tower locations, thereby delaying tower construction. If that dynamic introduced bias into our estimates we should find that controlling for various kinds of sectarian violence alters the results. Appendix Table A6 shows this is not the case. Panel (A) of reports the core specification of columns (6 and 7) from table (2), Panel (B) controls for total sectarian violence in a number of ways, and Panel (C) controls for targeted killings by sectarian organizations. None of the controls significantly alter our estimates of the impact of cellular coverage, providing additional confidence in the estimates in Table 1.

The third possibility, that insurgents trade quality for quantity when coverage increases, does not impact the validity of our net reduced form estimates, but does raise the issue of what the results imply. If cell phone coverage allows insurgents to be more effective with fewer attacks, then the policy implications of our findings are the opposite of what a more straightforward interpretation would suggest. The question is thus whether enhanced coverage allows insurgent to substitute quantity for quality at rates that should call into question the assessment that fewer attacks indicate a harder operating environment for insurgents.

Unfortunately, checking for such substitution is not possible at the district-month level as the SIGACT data do not include information on the consequences of attacks. What we can do is check whether there is substantial variation in the correlation between attack rates and casualty rates at the provincial level using the iCasualties.org data which give monthly figures for U.S. forces killed by province.[14] It turns out there is very little change over time in that relationship. The bivariate monthly correlation between total attacks and casualties is quite high, .61 for the entire period, and remains similarly strong by year, ranging from .51 in 2005 to .80 in 2007. Once we account for regional differences by using province fixed effects in a regression framework, the conditional correlation between casualties and total attacks is positive but statistically insignificant and does not

[14] For various tabulations of the data see www.iCasualties.org. We thank Radha Iyengar for providing these data in a readily usable Stata file.

change over time.[15] This consistency is hard to square with strong substitution effects, making us relatively confident that the reduced form relationship we identify shows that increased coverage makes it harder for insurgents to conduct attacks,

4.2 Mechanisms at the District-Month Level: Variation in regional effects

The effect of expanded cell phone coverage on insurgent attacks varies in informative ways across different insurgent tactics and across sectarian areas. Different kinds of insurgent attacks have different sensitivities to the productivity of labor and to information sharing by the population. In particular, direct fire attacks (e.g. ambushes) typically involve multiple individuals coordinating their actions but are sensitive to information sharing by the population, which can observe insurgents setting up. Indirect fire attacks (e.g. mortars) require less coordination and are less sensitive to information sharing as insurgents have great flexibility in choosing their firing position. IED attacks, require much less coordination around the point of attack than direct fire attacks and reveal less information to non-combatants, but remain sensitive to tips relative to indirect fire attacks, especially as tips about weapons caches can remove a large number of IEDs from circulation.[16]

As Table 2 shows, emplacing more towers reduces all types of attacks, but has heterogenous effects across the three main attack types. Panel (A) of Table 2 reports the core first differences model for each type of attack with district and month fixed effects, analogous to column (7) of Table 1. The effect is negative, but not statistically significant for direct fire attacks and positive but not statistically significant for indirect fire attacks. The effect is negative and statistically significant for total IED attacks attempted. The substantive effects are meaningful but not large. A one standard deviation increase in the number of towers introduced reduces the number of direct fire attacks in an average district-month by approximately 6.5%, and reduces the number of IEDs attempted by approximately 8.1%.

[INSERT TABLE 2 ABOUT HERE.]

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[15] Formally, we allow the slope of the casualty-incident relationship to vary by year using interaction terms and find no statistically meaningful slope shifts by year.

[16] Direct fire weapons such as AK-47s are ubiquitous throughout Iraq and so their supply is unlikely to be as sensitive to raids being conducted on the basis of tips.

What is more interesting about Table 2 is that the results are not particularly sensitive to controlling for periods which introduce the greatest concern about broad trends in violence creating spurious results. One such possibility is that towers built during 2008 when violence was rapidly declining could drive the results. Fortunately, Panel (C) shows this is not the case, the core results actually become substantially stronger when we drop 2008 from the analysis.[17]

A more serious concern is that the period of peak violence had few tower introductions, implying a greater level of care in the placement of towers, and so the results might be driven entirely by a strong the negative correlation for that period. Panel (D) checks this possibility by allowing a district-specific mean shift in each of three periods, the period before August 2006 when the rate of tower introduction dropped, the period through June 2007 when tower introduction was unusually slow, and the period after violence had peaked when tower introduction picked back up. The coefficients are almost identical to those in the core specification in Panel (A). This tells us that the average effect across periods is not driven by something specific to the middle period, but the slope may still vary by period. Appendix Table A7 reports the results of allowing the slope to vary by period. There we see that the slope is negative and statistically significant in the first period, strongly negative and statistically significant in the second period, and weakly positive but statistically insignificant in the third period. This finding is cause for both confidence and caution in our main results. On the confidence side, it can make us quite certain the result is not driven by towers being emplaced from mid-2007 on, when there was a broad secular decline in violence. On the cautious side, it confirms the theoretical ambiguity of the relationship between cellular communications and violence and should make one cautious about drawing overly strong policy conclusions from a relationship that is absent after mid-2007.

What about geographic heterogeneity? As Table 3 shows, it turns out that the results are substantively strongest in Sunni areas where per capita violence was highest. Column (1) of the table reports our core first differences specification, and the remaining columns report the results for

[17] 2008 is also the period when Zain began to have competition in the area of Iraq we study and so our data do not capture all cellular infrastructure being put in during that period. The fact that dropping it strengthens the results therefore provides additional confidence that the omitted variable bias from not having data from all providers is not a critical issue.

different sectarian subsets of the data. Column (5) combines Sunni and mixed areas, showing that the average effect across the parts of the country where the war was really fought is negative and substantively modest, so that a one standard deviation increase in towers in these areas led to 3.9 fewer attacks in the next month (1.9*-.496*4.176), a 12.3% reduction. Columns (6) report the results for ethnically homogenous districts, where 80% of the population or more is from one sect, and column (7) shows the results for non-homogenous districts. The effects are substantively similar across these areas, with the standard errors being much larger in the non-homogenous districts because of the smaller sample size. Appendix Table A8 breaks these results down by both attack type and sectarian region, showing that the effects are driven by Sunni and mixed areas, which makes sense as there were relatively few insurgent attacks in Shia and Kurdish districts, and that the reduction in direct fire attacks is strongest in Sunni areas is far and away the strongest effect.

[INSERT TABLE 3 ABOUT HERE.]

What do these patterns imply? First, they suggest the information channel is key. The effects of expanded coverage are strongest in Sunni areas, which are the regions where we might expect that (a) Coalition forces' ability to run human sources would be weakest and (b) in-group policing by insurgents would be most effective. Both imply that the impact of expanding coverage should be relatively large as it creates a collection channel for signals intelligence that did not exist before and provides people a safe way to share tips. Second, the effects are of similar magnitude for direct fire and IED attacks (nearly identical if we drop 2008 from the analysis), making it seem unlikely that expanding coverage substantially eased coordination. If it had, the effect on direct fire attacks, which require more coordination, should have been muted.

4.3 LOCAL IMPACT OF CELL PHONES: TOWER-LEVEL RESULTS

Despite the rich set of robustness checks provided above, an additional set of regressions taking advantage of the spatial nature of cell-phone expansion can provide greater confidence in our core results and may provide evidence as to the mechanisms at play. At the same time, it is important to keep in mind that the tower-level results are not testing the same relationships as the district-level ones. While know that at some insurgent groups organized geographically along pre-existing district lines,[18] we have no similar reason to think violence was organized within tower catchments. The tower-level analysis is therefore unlikely to isolate changes caused by enhanced passive intelligence collection. Instead it identifies towers' influence on local tactical dynamics, either by making it safer for people to share information or by enhancing the viability of remotely fusing IEDs and helping to coordinating ambushes.

The key to our tower level approach is that some towers simply enhance service that was already available, while other towers extend service into new areas. If violence declines because towers are introduced, and not because of some omitted variable driving introduction and violence, we should see violence goes down around towers that provide new coverage, but not around those that simply enhance existing service. If, however, violence declines because of some omitted variable, say because the providers are good at anticipating where violence will drop, we should see post-introduction declines in both areas.

An effective way to implement this approach is to use a standard difference-in-differences design where our estimate of the treatment effect is just $E[(\mathbf{a}_{\mathbf{post}} - \mathbf{a}_{\mathbf{pre}}) - (\mathbf{b}_{\mathbf{post}} - \mathbf{b}_{\mathbf{pre}})]$ where **a** is a vector of violence in towers that provide new coverage and **b** is the analogous vector for towers that simply deepen existing coverage. This logic gives us the following core estimating equation:

$$(4) \qquad v_{i,t} = \beta_1 post_t + \beta_2 (post_t * new_i) + f_i + q_t + \varepsilon_{i,t},$$

where f_i is a slice fixed-effect, q_t is a quarter fixed effect to control for secular trends in the conflict, the $post_t$ variables is a dummy variable that takes a value of 1 after tower introduction, and $post_t * new_i$ is a dummy variable which takes a value of 1 in new coverage areas after towers are turned on. Since the threshold for what should constitute a new coverage area is not obvious, Zain always sought some overlap so there are almost no entirely new areas, our core analysis shows what happens as we vary the threshold for being a 'new' tower from 10% new coverage to 90%. The key coefficient to focus on is β_2 which tells us how much the trend around towers that provide substantial new coverage differs from the trend around similar towers that extend existing coverage.

[18] On Al-Qa'ida in Iraq see Bahney et. al. (2011).

Appendix Table A9 provides descriptive statistics for the 1,859 coverage areas created by towers established between 14 June 2004 and 26 October 2008, of which 1,787 experienced at least one violence incident in our data. These are the slices for which we have eight full 15-day periods of violence data (120 days) before and after the towers were established. To estimate the area covered by each tower we use a 4km radius in urban areas and 12km one in rural areas.[19] Panels (A) and (B) provide key characteristics for the full sample, panels (C) and (D) do the same for the towers that are have at least a 50% overlap with existing towers, and panels (E) and (F) provide information for towers that cover more than 50% new territory. As we can see, towers reinforcing existing coverage typically serve larger populations and experience more total violence, though substantially less per capita. This is, of course, because few new towers are needed in sparsely populated rural areas, while increasing adoption of cell phones created demand for greater capacity in urban areas, requiring Zain to introduce more towers and 'split cells' to maintain service and maximize its profits. Under the identifying assumption for the difference-in-differences estimate, that differencing accounts for unit-specific characteristics, these time invariant differences in slices should not bias the estimation, though we will discuss how it might and why we think it unlikely.

To estimate the impact of cellular communications for specific areas we would like to know how levels of violence within towers' coverage areas change between the period immediately before a tower is introduced and the period immediately after. This approach identifies a causal impact if the timing of tower introduction is random conditional on our controls. We argued above that after accounting for annual marketing decisions, the week-to-week timing of tower introduction is largely random given the exigencies of actually building the network. Fortunately, we can do better than weighing in on the theological validity of that position. Our difference-in-differences approach tests it by using the portion of the area covered by a new tower that already has coverage as a placebo.

Table 4 shows that mean levels of violence per 15-day period at the tower level are much lower in the 120 days after towers are introduced than before in new areas, but not in old areas.

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[19] Precise coverage estimates do not exist for Iraq and all major modeling software requires substantial input we have not been able to get from Zain. The 12km and 4km figures are based on an extensive effort to precisely model Zain's coverage with colleagues in Electrical Engineering, Professor Mung Chiang and Dr. Haris Kremo. Details available upon request.

Panel (A) shows the results of the standard difference-in-differences regression, which does not account for secular trends. Panel (B) shows the results controlling for broad secular trends with quarter fixed-effects. The difference is striking. The positive change in average per-period violence after tower introduction in areas where towers reinforce coverage that we see in panel (A) is an artifact of secular trends. Once quarter fixed-effects are added that positive mean shift disappears but the negative mean shift in areas where towers add 10% or more new coverage remains substantively and statistically strong. Indeed, in panel (B) the reduction in violence from 'new' towers is statistically robust and substantively consistent across coverage thresholds. At the 50% threshold, turning a tower with new coverage on predicts 896 fewer attacks per period, more than half the mean level of violence in tower areas that provide 50% new coverage.

[INSERT TABLE 4 ABOUT HERE.]

Once we net out the broad secular trends, it appears that introducing coverage is violence reducing at the local level, but that building more towers in already-covered areas is not. Table 5 shows that, just as with the district-level results, the effect is statistically strongest for IED attacks. The impact of coverage is positive for indirect fire attacks but statistically insignificant for more lenient interpretations of what constitutes new coverage. This is consistent with an information mechanism in so far as it indicates tactical substitution wherein insurgents seeking to attack newly-covered areas do so with methods that do not require that they physically go there.

[INSERT TABLE 5 ABOUT HERE.]

The tower-level effects do vary a bit by period, though the introduction of new coverage always reduces violence relative to overall trends in tower catchment areas that do not expand coverage. Appendix Table A10 reports these results by attack type. Panel A excludes towers turned on during the period in 2006-7 when tower construction slowed. Panel B drops towers built after 2007. The results mirror those in in the full sample as there is a clear negative impact of towers that provide at least 20% new coverage on IED attacks relative to the change in tower catchments that provide less than that. Our ability to control for broad secular trends in areas getting new towers is reduced when we exclude certain periods (the mean shift after tower introduction in already-covered is statistically significant in many of these models), however the core result that violence drops more in tower catchments that introduce substantial new coverage (the interaction term) remains robust.

For one to believe the tower-level results are driven by omitted variable bias it would have to be the case that the correlation between future violence and the week-to-week timing of where towers are placed is massively stronger for towers that provide new coverage than for towers installed at the same time that do not. That seems unlikely, particularly as the correlation between the proportion of new coverage a tower provides and total violence over the 120 days after construction is negligible once district-specific violence has been taken into account.[20]

Overall then, the tower level results provide additional evidence that the effect of information flowing to Coalition forces is key mechanism driving the panel data results. Introducing cell phone coverage has clear localized impact in reducing the number of IEDs in new coverage areas but not in previously covered areas. This is particularly striking as putting coverage over an area increases the range of IED fusing options which should, if anything, decrease the proportion counterinsurgents can successfully neutralize.

5. Conclusion

This paper presents the first systematic examination of the effect of cellular communications on political violence using novel micro-level data from Iraq. We find that cell phone network expansion reduced insurgent violence at both the district-level and within specific tower coverage areas. Taken together, these findings suggest the mechanism driving the impact of cellular communications on violence is increased information flow to counterinsurgents. Our data are ambiguous about whether this is because coverage enhances voluntary information flow from non-combatants by reducing the risks of informing, or because insurgents using cell phones present a good target for government intelligence gathering efforts, but the net effect is clear.

These results speak to a number of literatures. First, they contribute to a growing body of literature demonstrating the beneficial effects of expanding communications opportunities (Jensen

[20] In other words, controlling for violence at a level of geographic aggregation that is much larger than the tower-specific fixed effects used in all the regressions in this section removes the correlation we would expect if there were a strong relationship between violence and the amount of new coverage towers provide. Results available on request.

2011, Aker 2008). Our findings suggest cellular communications may confer a range of governance and stability advantages that have not previously been tested in this literature.

Second, the results also speak to debates about what kinds of ethnic concentrations increase the risk of civil war (Weidmann 2009) and to discussions of why insurgencies are more successful when operating from rural areas (Kocher 2004; Bates 2008; Staniland 2010). The question at issue in these debates is whether urban terrain makes it easier or harder for state security forces to control violent groups. The key argument on the 'easier' side is that in urban areas many people necessarily have information on the insurgents, by virtue of simple population density, which makes them acutely vulnerable to informants. By showing that exogenous environmental changes which reduce the cost of informing leads to a clear and unambiguous reduction in insurgent violence, we provide solid empirical grounding for a mechanism discussed, but never tested, in this literature.[21]

Third, and perhaps most importantly, these results are highly relevant to ongoing policy in all countries facing active insurgencies and the need to grow their wireless infrastructure. For countries such as Colombia, India, Pakistan, and Thailand, the policy debates typically hinge on how tightly regulated access to phones and SIM cards should be. For the international community the debates are about the extent to which the expansion of cellular communications should be subsidized. In Afghanistan, for example, there have been ongoing discussion about whether or not foreign governments and aid agencies should work with telecommunications firms that make compromises with local militants in order to protect their towers and staff. Much of the policy community currently argues there should be little engagement so long as towers are being turned off at night when the Taliban demands. Our analysis suggests this approach may be wrong-headed. If in addition to their economic impact towers that are on only part of the day confer counterinsurgency benefits, as we show towers which are on all day do, then the international community may well want to subsidize the expansion of the Afghan cell phone network regardless of how the firms managing the network interact with the locals.

[21] We thank Jim Fearon for pointing out this connection.

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Figures

Figure 1: Expansion of the Zain Iraq Network, 2004-2009

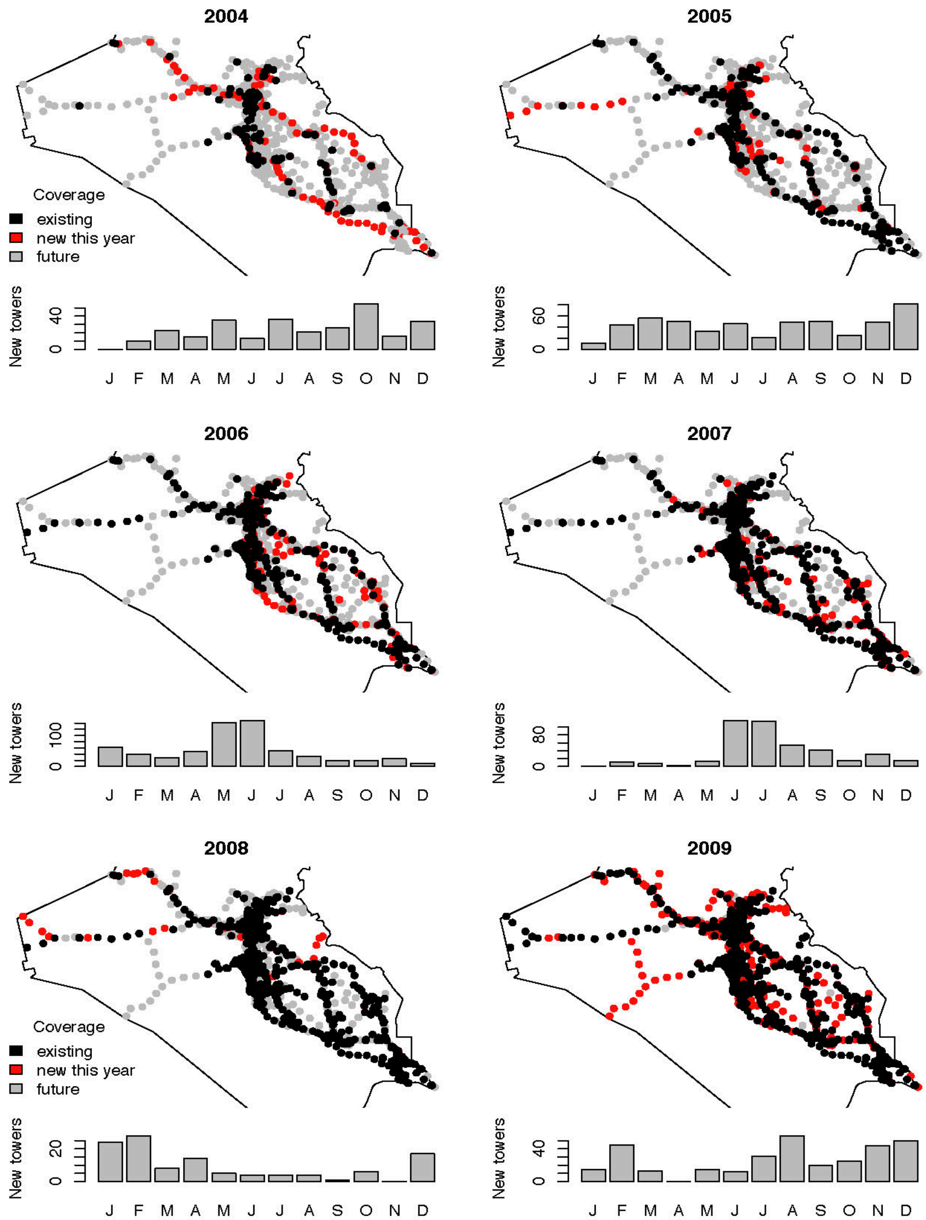
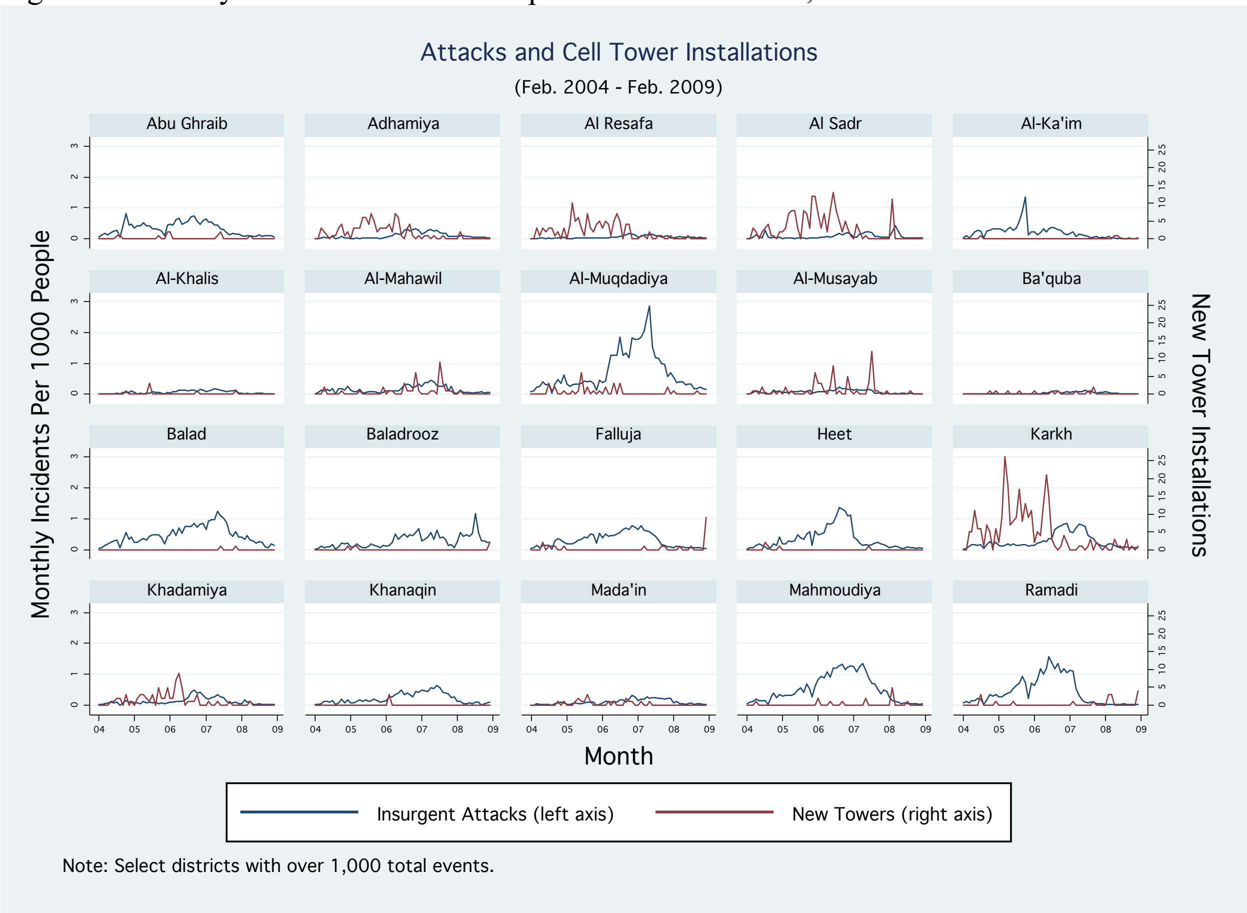
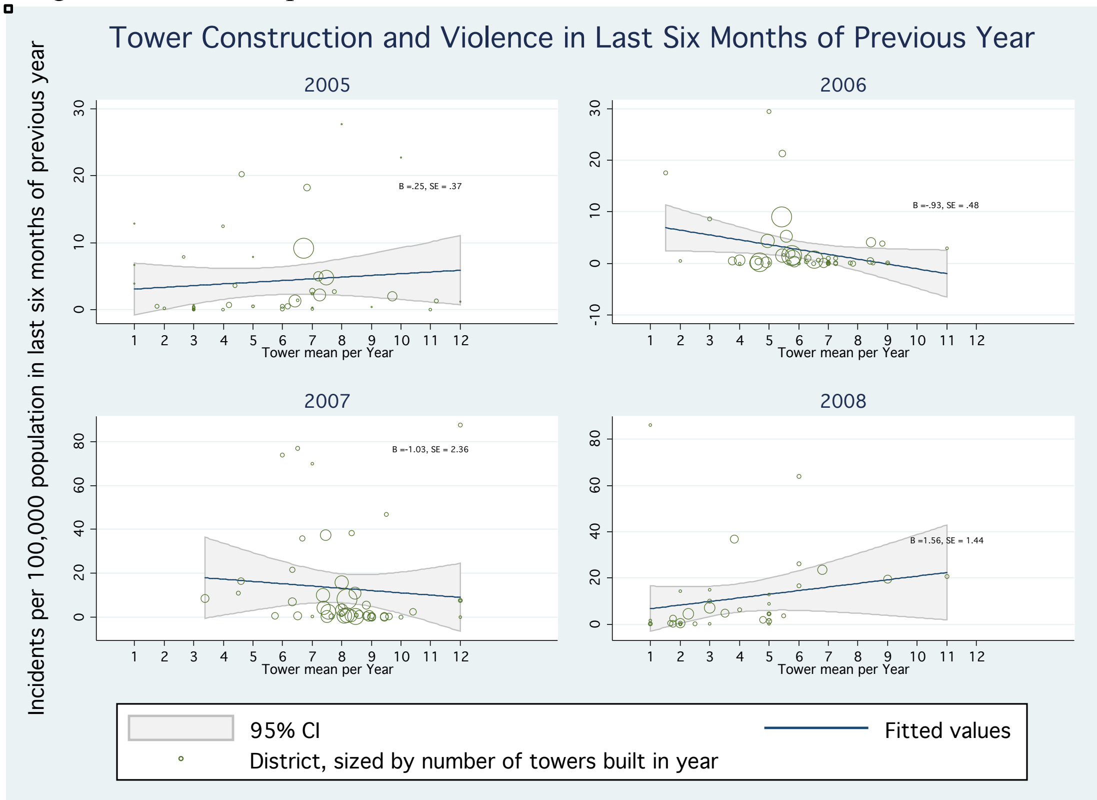


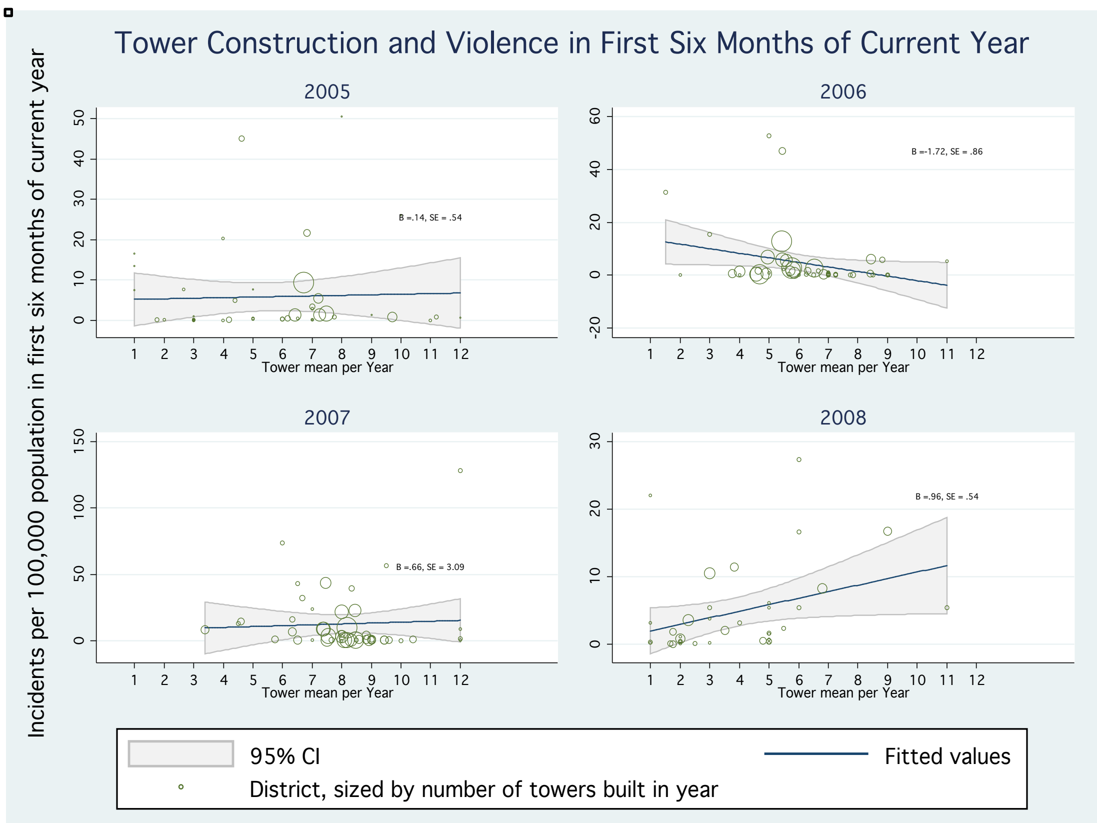
Figure 2: Monthly Trends in Network Expansion and Violence, Select Districts



Note: Unit of analysis is the district month. Violence data are from MNF-I SIGACT-III database. Population data are from World Food Program Food Security and Vulnerability Analysis surveys fielded in 2004:I, 2005:II, and 2007:I. Data on cell phone tower installations provided by Zain Iraq.

Figure 3 Relationship between Violence and Tower Construction at District/Month





Tables

Table 1. Impact of Increased Cell Phone Coverage on Total Attacks – District/Month

Dependent Variable:	(1) SIGACT /100,000	(2) SIGACT /100,000	(3) SIGACT /100,000	(4) FD of SIG /100,000	(5) FD of SIG /100,000	(6) FD of SIG /100,000	(7) FD of SIG /100,000	(8) FD of SIG /100,000	(9) FD of SIG /100,000	(10) FD of SIG /100,000
New Towers in *t*-1	-0.815*	-0.640**	-0.857**							
	(0.44)	(0.25)	(0.39)							
Lagged First Difference of Tower Count				-0.0780	-0.0882*	-0.115**	-0.149**	-0.0887*	-0.0952*	-0.188*
				(0.047)	(0.049)	(0.056)	(0.070)	(0.054)	(0.055)	(0.11)
Existing Tower Count		-0.0251	-0.0873							
		(0.033)	(0.071)							
Sunni Proportion	40.01**	40.60**	30.69							
	(16.8)	(17.4)	(29.3)							
Shia Proportion	-4.101	-3.560	-10.88							
	(6.51)	(7.04)	(25.1)							
Observations	3717	3717	3717	3654	3654	3654	3654	3654	3654	3654
R-squared	0.28	0.28	0.31	0.01	0.01	0.07	0.07	0.03	0.06	0.07
Time FE	Half	Half	Half	Half	Quarter	Month	Month	Sect X Half	Sect X Quarter	Province X Quarter
Space FE	No	No	Province	No	No	No	District	No	No	No
First Differences	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain Iraq operated during period under study. Robust standard errors, clustered at the district level in parentheses. Each model's fixed effects are noted. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007).

Table 2. Impact of Increased Cell Phone Coverage by Attack Type

Dependent Variable: FD of Attacks/100,000	(1) All Attacks	(2) Direct Fire	(3) Indirect Fire	(4) Total IED Attempts
Panel A: Full Sample				
Lagged FD of Towers	-0.149**	-0.0449	0.00525	-0.065*
	(0.070)	(0.033)	(0.0083)	(0.037)
Observations	3654	3654	3654	3654
R-squared	0.07	0.03	0.09	0.05
Panel B: Full Sample with Spatial Lag				
Lagged FD of Towers	-0.140**	-0.0443	0.0049	-0.056*
	(0.069)	(0.033)	(0.008)	(0.032)
Spatial Lag of DV	0.0323***	0.0106**	0.0022	0.0433***
	(0.008)	(0.0042)	(0.004)	(0.013)
Observations	3654	3654	3654	3654
R-squared	0.12	0.04	0.09	0.12
Panel C: Without 2008				
Lagged FD of Towers	-0.184**	-0.0631*	0.0045	-0.075**
	(0.075)	(0.037)	(0.009)	(0.036)
Observations	2898	2898	2898	2898
R-squared	0.07	0.03	0.09	0.06
Panel D: With Period-Specific District Fixed-Effects (Period Breaks at August 2006 and June 2007)				
Lagged FD of Towers	-0.149**	-0.050	0.007	-0.062*
	(0.068)	(0.034)	(0.008)	(0.034)
Observations	3654	3654	3654	3654
R-squared	0.11	0.05	0.12	0.08

Notes: Unit of analysis for violence is district/month, February ‘04 – January ’09. Analysis restricted to 63 districts in which Zain operated during period under study. Robust standard errors, clustered at the district level in parentheses. All results include district and month fixed effects. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007).

Table 3. Impact of Increased Cell Phone Coverage by Sectarian Area

Dependent Variable: Attacks/100,000	(1) All Areas	(2) Mixed	(3) Kurd/Shia	(4) Sunni	(5) Mixed/Sunni	(6) Ethnically Homogenous	(7) Non-Homogenous
Lagged FD of Towers	-0.149** (0.070)	-0.251 (0.19)	-0.00960 (0.058)	-2.259* (1.07)	-0.496* (0.29)	-0.195** (0.083)	-0.184 (0.15)
Observations	3654	580	2436	638	1218	2784	870
Number of Districts	63	10	42	11	21	48	15
R-squared	0.07	0.30	0.10	0.23	0.18	0.06	0.21

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain operated during period under study. Robust standard errors, clustered at the district level in parentheses. All results include month and district fixed effects. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007). Sectarian areas coded as Kurdish/Shia or Sunni if greater than 60% of population is from that affiliation, mixed otherwise.

Table 4: Impact of Introducing Cellular Communications for Tower Areas.

Panel A: Standard Difference-in-Differences

Coverage Threshold for `New' Towers	(1) 10%	(2) 20%	(3) 30%	(4) 40%	(5) 50%	(6) 60%	(7) 70%	(8) 80%	(9) 90%
Post	1.093***	1.022***	1.009***	0.971***	0.967***	0.947***	0.930***	0.921***	0.911***
	(0.21)	(0.20)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.18)
*Post*New*	-1.001***	-0.874**	-0.904**	-0.682**	-0.737***	-0.637**	-0.520*	-0.461	-0.423
	(0.31)	(0.34)	(0.37)	(0.31)	(0.27)	(0.28)	(0.28)	(0.29)	(0.32)
Observations	29,744	29,744	29,744	29,744	29,744	29,744	29,744	29,744	29,744
Number of Towers	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859
R-squared	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74

Panel B: Quarter Fixed-Effects to Control for Secular Trends

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post	-0.0779	-0.147	-0.169	-0.216	-0.219	-0.238	-0.243	-0.252	-0.266
	(0.20)	(0.19)	(0.19)	(0.19)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)
*Post*New*	-1.026***	-0.920**	-0.901**	-0.608*	-0.677**	-0.589*	-0.599*	-0.547	-0.487
	(0.32)	(0.37)	(0.40)	(0.35)	(0.31)	(0.33)	(0.34)	(0.35)	(0.39)
Observations	29,744	29,744	29,744	29,744	29,744	29,744	29,744	29,744	29,744
Number of Towers	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859
R-squared	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

Notes: Unit of analysis is tower areas for 15-day periods in relative time from tower onair date. Coverage areas created by a 4km radius around cell phone towers in urban areas and 12km radius in rural areas. Robust standard errors, clustered at the tower level in parentheses. All specifications include tower fixed effects. Estimates significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent Events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008).

Table 5. Impact of Increased Cell Phone Coverage by Attack Type at Different Thresholds

Dependent Variable:	(1) All Attacks	(2) Direct Fire	(3) Indirect Fire	(4) Total IED Attempts
Panel A: Coverage Threshold for `New' Towers = 20%				
Post	-0.147	-0.168	-0.0213	-0.0725
	(0.19)	(0.11)	(0.042)	(0.088)
*Post*New*	-0.920**	-0.248	0.0629	-0.427***
	(0.37)	(0.19)	(0.050)	(0.13)
Observations	29744	29744	29744	29744
R-squared	0.75	0.64	0.31	0.80
Panel B: Coverage Threshold for `New' Towers = 50%				
Post	-0.219	-0.189*	-0.0253	-0.0898
	(0.18)	(0.10)	(0.041)	(0.085)
*Post*New*	-0.677**	-0.164	0.124**	-0.452***
	(0.31)	(0.16)	(0.056)	(0.13)
Observations	29744	29744	29744	29744
R-squared	0.75	0.64	0.31	0.80
Panel C: Coverage Threshold for `New' Towers = 80%				
Post	-0.252	-0.197**	-0.0248	-0.108
	(0.18)	(0.097)	(0.040)	(0.083)
*Post*New*	-0.547	-0.133	0.167***	-0.410***
	(0.35)	(0.17)	(0.058)	(0.15)
Observations	29744	29744	29744	29744
R-squared	0.75	0.64	0.31	0.80

Notes: Unit of analysis is tower areas for 15-day periods in relative time from tower onair date. Coverage areas created by a 4km radius around cell phone towers in urban areas and 12km radius in rural areas. Robust standard errors, clustered at the tower level in parentheses. All specifications include tower and quarter fixed effects. Estimates significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent Events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008).

Online Appendix A:

The following simple model frames the discussion of how increasing cellular communications could influence observed levels of violence.

Suppose that insurgents' production of violence at any point in time requires two inputs: labor, *l,* and organizational capital, *c*, which captures a range of factors including monetary resources, weaponry, and organizational infrastructure. To capture the intuition that cell phone coverage makes it easier to coordinate insurgent activity let the marginal product of labor be increasing in the level of cell phone coverage, which we will call κ. The production of violence is restricted by the ability of counterinsurgents to attack the group, destroying a portion of its production. Counterinsurgents capacity to attack is a function of their force levels as a proportion of the total population, *f*, and the amount of tactically-relevant information—the location of weapons caches, identities of insurgents, and the like—shared by the population, *i*. The more information is shared, the more efficiently counterinsurgents can capture/kill insurgents and defend their installations. To capture the intuition that the level of information is increasing in the ease of communicating tips (or of listening to insurgents' communications) let the amount of information shared be increasing in κ.

Assuming insurgents produce at capacity, total violence produced in any period can be represented with a Cobb-Douglas production function:

$$(1) \qquad V = (l^{a(\kappa)} c^b)(1 - fi(\kappa)),$$

where $f, i \in [0,1]$, with $i = 1$ implying that all tactically relevant information is shared.[1] To match our intuition on the potential effects of cell phone coverage assume $a'(\kappa)$, $i'(\kappa) > 0$. Taking the derivative of the log of (1) with respect to κ yields the intuitive condition for when the level of violence will be increasing in communications:

$$(2) \qquad a'(\kappa)\ln(l) > \frac{fi'(\kappa)}{1 - fi(\kappa)}.$$

It is obvious that this condition is more likely to be met when insurgent labor is plentiful and when the marginal impact of increasing communications on the productivity of insurgent labor is large. The condition is less likely to be met when counter-insurgent force levels are large, when the impact on information flow of increasing communications is large, and when the level of information flow at existing levels of communication are large.

[1] See Hanson, Iyengar, and Monten (2009) for an explicit analysis of insurgent substitution between capital and labor in the production of violence. For the comparative statics that interest us what matters is that insurgents are at the production frontier before the increase in cell phone coverage, so that regardless of the reallocation following a the change in coverage, there will be more or less violence depending on whether the condition in (2) is met.

Online Appendix Tables and Figures

This appendix contains supplementary tables for “Cell Phones and Insurgent Violence in Iraq.” These figures and tables are as follows:

- Figure A1 shows a cell-phone fused IED.
- Figure A2 shows a tip-card.
- Figure A3 shows the national trends in tower construction.
- Figure A4 shows the national trends in network expansion and violence.
- Figure A5 Replicates Figure 3 with violence in the last six months of the year.
- Table A1 shows the bivariate correlation between violence and dates of tower introduction in Figure 7 are statistically insignificant once sect fixed-effects are accounted for.
- Table A2 shows the summary statistics for the district/month panel dataset.
- Table A3 replicates Table 1 with the inclusion of a spatial lag of the DV.
- Table A4 replicates Table 3 with the leads of key IV on the RHS.
- Table A5 replicates Table 3 with the spatial lags of key IV on the RHS.
- Table A6 replicates column (7) from Table (3) controlling for past sectarian violence.
- Table A7 shows that the estimated slope of the relationship is heterogeneous across periods, becoming positive in the later period.
- Table A8 disaggregates the impact of increased cell phone coverage by attack type and sect.
- Table A9 provides summary statistics for the local analysis of tower coverage areas.
- Table A10 breaks the impact of increased coverage down by both sectarian region and attack type.

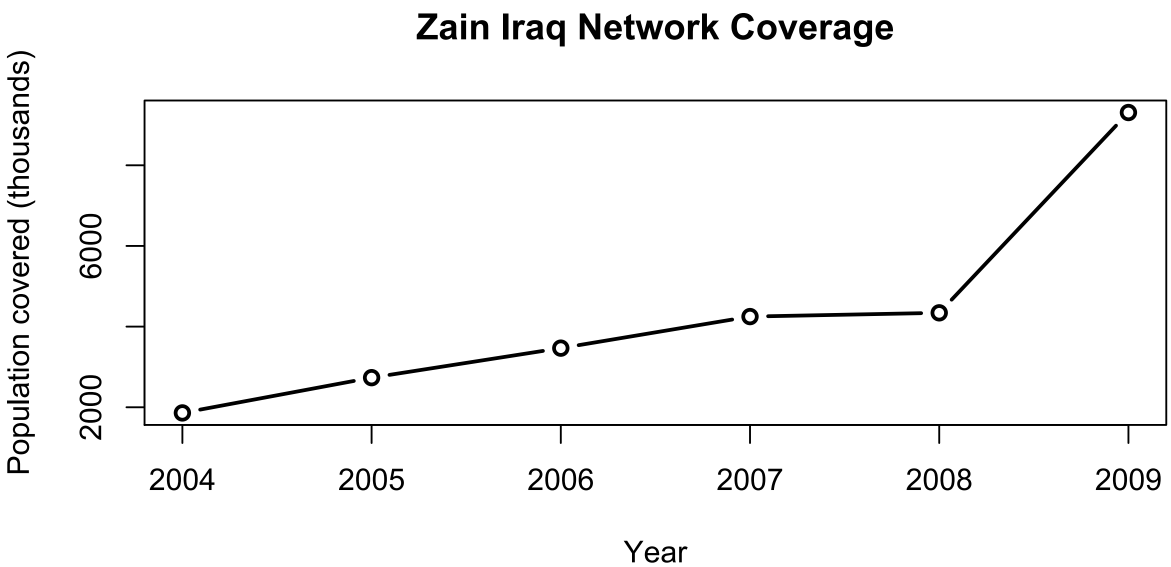
Figure A1. Cell-Phone Triggered Improvised Explosive Device

Figure A2: Tip Line Card

Note: A card handed out by soldiers from the U.S. Army 3rd Infantry Division providing contact information for a government-run tip line. The card reads as follows:

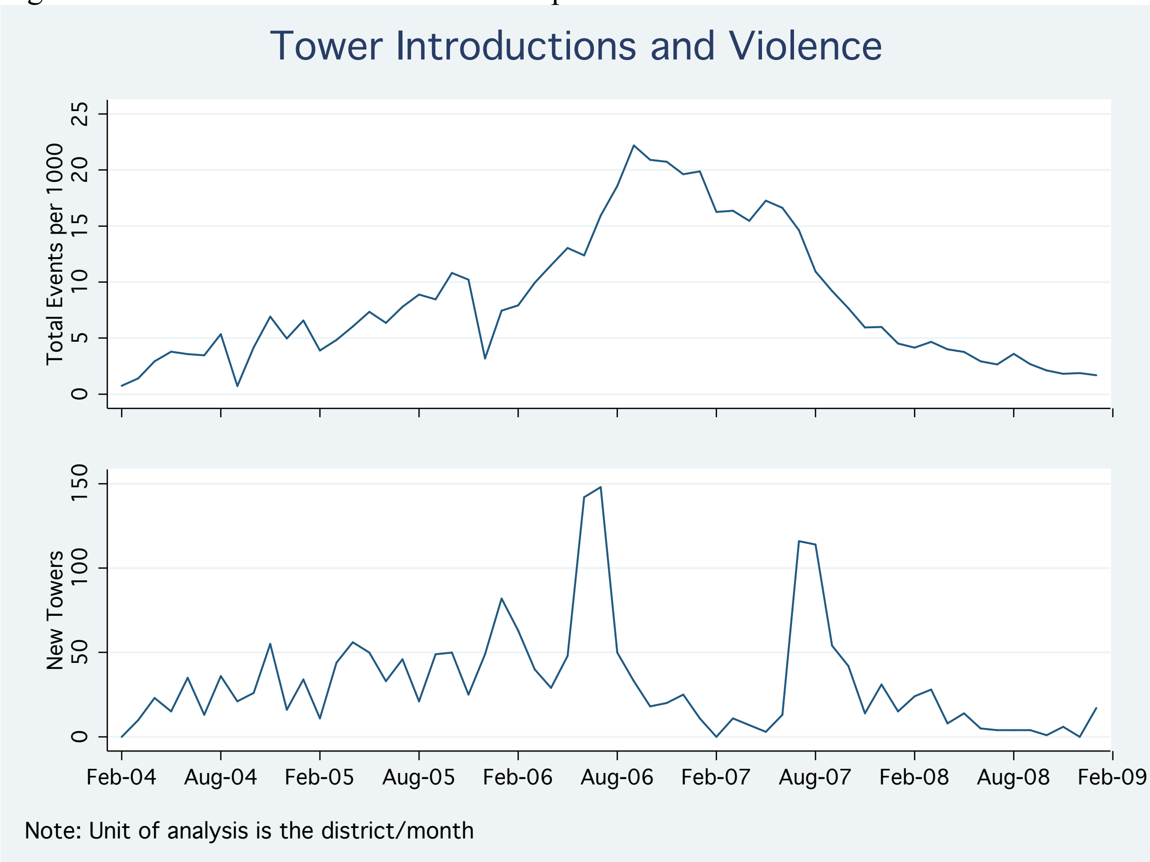
> "Have you seen, heard or become aware of criminal activities or those hostile to Iraq? Do you wish you could do something about it? You can!! Talk anonymously and help your country by giving news about crimes or actions hostile to Iraq. Fulfill your duty to take care of your children, your loved ones and society. You may phone or text to this number: 07712477623. Give any information you want, no names needed. The way YOU can fight is by calling this number: 07712477623."

Figure A3. Expansion of Coverage by Population, 2004-2009



Source: Author calculations cell tower data provided by Zain Iraq and LandScan (2008) gridded population data. Coverage areas estimated with 4km radius in urban areas and 12km radius in rural areas.

Figure A4: National Trends in Network Expansion and Violence



Note: Unit of analysis is the month. Violence data are from MNF-I SIGACT-III database. Population data are from World Food Program Food Security and Vulnerability Analysis surveys fielded in 2004:I, 2005:II, and 2007:I. Data on cell phone tower installations provided by Zain Iraq.

Figure A5: Impact of Current Year Violence on Tower Construction at District/Month

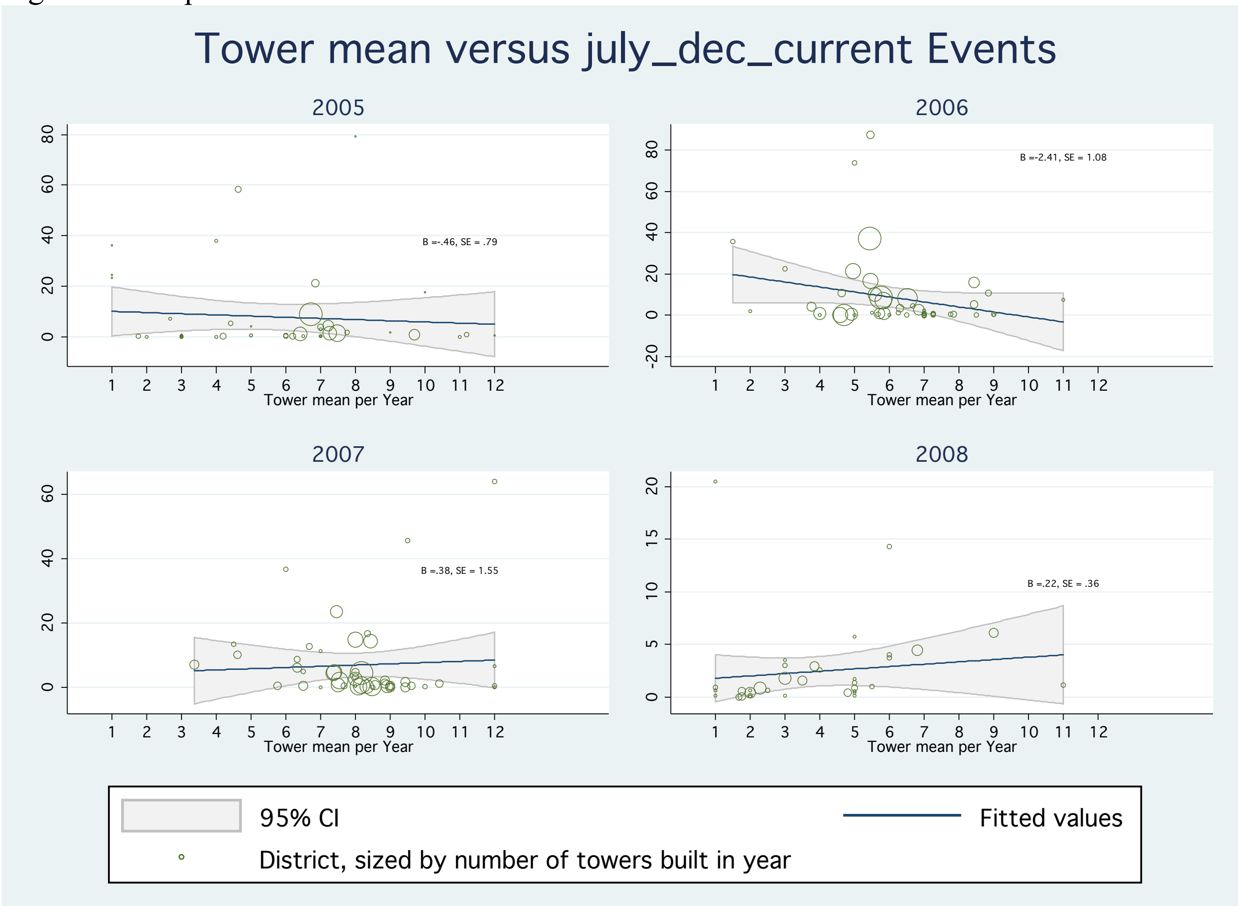


Table A1. Relationship Between Violence and Average Month of Tower Introduction

Panel 1: DV = Aggregate Violence in July-December of Previous Year		Full Sample	2005	2006	2007	2008
	Panel 1A: Bivariate Regression					
	July-December Violence	0.299	0.254	-0.937*	-1.034	1.561
		(0.55)	(0.38)	(0.48)	(2.36)	(1.45)
	Observations	177	44	49	48	36
	R-squared	0.00	0.01	0.09	0.01	0.04
	Panel 1B: Sect Fixed Effects					
	July-December Violence	0.219	0.283	-0.731	-0.250	-2.138
		(0.46)	(0.19)	(0.79)	(2.15)	(3.01)
	Observations	177	44	49	48	36
	R-squared	0.32	0.39	0.44	0.49	0.42

Panel 2: DV = Aggregate Violence in January-July of Current Year		Full Sample	2005	2006	2007	2008
	Panel 2A: Bivariate Regression					
	January-June Violence	0.662	0.143	-1.721*	0.663	0.969*
		(0.63)	(0.54)	(0.87)	(3.09)	(0.55)
	Observations	177	44	49	48	36
	R-squared	0.01	0.00	0.08	0.00	0.11
	Panel 2B: Sect Fixed Effects					
	January-June Violence	0.593	0.296	-1.342	2.015	-0.279
		(0.68)	(0.32)	(1.46)	(3.02)	(0.69)
	Observations	177	44	49	48	36
	R-squared	0.29	0.47	0.44	0.39	0.44

Panel 3: DV = Aggregate Violence in July-December of Current Year		Full Sample	2005	2006	2007	2008
	Panel 3A: Bivariate Regression					
	July-December Current Year Violence	-0.0707	-0.465	-2.413**	0.383	0.223
		(0.40)	(0.79)	(1.09)	(1.55)	(0.36)
	Observations	177	44	49	48	36
	R-squared	0.00	0.01	0.06	0.00	0.02
	Panel 3B: Fixed Effects					
	July-December Current Year Violence	-0.141	-0.157	-1.829	0.874	-0.614
		(0.32)	(0.40)	(2.01)	(1.56)	(0.81)
	Observations	177	44	49	48	36
	R-squared	0.29	0.56	0.47	0.36	0.40

Note: Robust standard errors in parentheses for all regressions, clustered by sectarian region for regressions with sect fixed-effects. Sect fixed effects account for distinct mean levels of violence in 9 Sunni/Kurd districts, 13 mixed districts, and 41 majority Shia districts. 75 of 252 district-years had no towers introduced and so are not included in regressions, representing 40 different districts of which 9 are predominantly Sunni or Kurdish, 7 are mixed, and 24 are predominantly Shia. Constants not reported. *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Summary Statistics – District/Month

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Panel A: Violence Variables					
SIGACTs / 100,000	3,780	13.21	34.92	0	481
Attacks / 100,000	3,780	12.04	32.82	0	453
Direct Fire / 100,000	3,780	3.25	10.26	0	156
IED Attempts /100,000	3,780	6.91	19.76	0	311
Sectarian Killings/100,000	3,780	1.79	6.63	0	170
Targeted Killings/100,000	3,780	0.648	4.74	0	170
Panel B: Control Variables					
New Towers	3,780	0.519	1.833	0	35
Total Towers Active	3,780	18.74	38.67	0	296
Population (1000)	3,780	327	320	11	1662
Proportion Sunni	3,780	0.243	0.355	0	1
Proportion Shia	3,780	0.742	0.371	0	1

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Violent events based on data on MNF-I SIGACT-III database. Civilian casualty data from Iraq Body Count collaboration with ESOC. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007). Analysis restricted to 63 districts in which Zain operated during period under study.

Table A3. Impact of Increased Cell Phone Coverage on Total Attacks with Spatial Lag of DV – District/Month

Dependent Variable:	(1) SIGACT /100,000	(2) SIGACT /100,000	(3) SIGACT /100,000	(4) FD of SIG /100,000	(5) FD of SIG /100,000	(6) FD of SIG /100,000	(7) FD of SIG /100,000	(8) FD of SIG /100,000	(9) FD of SIG /100,000	(10) FD of SIG /100,000
New Towers in *t*-1	-0.470	-0.452**	-0.661**							
	(0.29)	(0.18)	(0.31)							
Lagged First Difference of Tower Count				-0.0719	-0.0812	-0.108*	-0.140**	-0.0841	-0.0916	-0.180*
				(0.048)	(0.049)	(0.056)	(0.069)	(0.054)	(0.056)	(0.097)
Existing Tower Count	0.0301	0.0300	0.0334	0.0384***	0.0379***	0.0323***	0.0323***	0.0366***	0.0341***	0.0344***
	(0.023)	(0.023)	(0.022)	(0.0091)	(0.0090)	(0.0079)	(0.0080)	(0.0083)	(0.0080)	(0.0087)
Sunni Proportion		-0.00254	-0.0671							
		(0.023)	(0.062)							
Shia Proportion	26.62**	26.70**	16.91							
	(10.8)	(11.2)	(27.8)							
New Towers in *t*-1	-5.316	-5.259	0.628							
	(5.81)	(6.04)	(24.6)							
Observations	3717	3717	3717	3654	3654	3654	3654	3654	3654	3654
R-squared	0.34	0.34	0.37	0.09	0.10	0.12	0.12	0.10	0.12	0.14
Time FE	Half	Half	Half	Half	Quarter	Month	Month	Sect X Half	Sect X Quarter	Province X Quarter
Space FE	No	No	Province	No	No	No	District	No	No	No
First Differences	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Unit of analysis for violence is district/month, February ‘04 – January ’09. Analysis restricted to 63 districts in which Zain Iraq operated during period under study. Robust standard errors, clustered at the district level in parentheses. Spatial lags are total of given variable in neighboring districts, Each model’s fixed effects are noted. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007).

Table A4. Temporal Placebo Test of Impact of Increased Cell Phone Coverage on Total Attacks – District/Month

Dependent Variable:	(1) SIGACT /100,000	(2) SIGACT /100,000	(3) SIGACT /100,000	(4) FD of SIG /100,000	(5) FD of SIG /100,000	(6) FD of SIG /100,000	(7) FD of SIG /100,000	(8) FD of SIG /100,000	(9) FD of SIG /100,000	(10) FD of SIG /100,000
New Towers in *t* +1	-0.794*	-0.595**	-0.820**							
	(0.43)	(0.24)	(0.38)							
Lead First Difference of Tower Count				0.0148	0.00348	0.0728	0.0948	-0.00794	-0.0351	-0.115
				(0.048)	(0.052)	(0.064)	(0.081)	(0.050)	(0.053)	(0.10)
Existing Tower Count		-0.0286	-0.0911							
		(0.034)	(0.072)							
Sunni Proportion	40.19**	40.88**	30.63							
	(16.8)	(17.4)	(29.3)							
Shia Proportion	-3.872	-3.230	-10.53							
	(6.55)	(7.12)	(25.1)							
Observations	3717	3717	3717	3654	3654	3654	3654	3654	3654	3654
R-squared	0.27	0.27	0.30	0.01	0.02	0.07	0.07	0.05	0.07	0.09
Time FE	Half	Half	Half	Half	Quarter	Month	Month	Sect X Half	Sect X Quarter	Province X Quarter
Space FE	No	No	Province	No	No	No	District	No	No	No
First Differences	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain Iraq operated during period under study. Robust standard errors, clustered at the district level in parentheses. Each model's fixed effects are noted. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007).

Table A5. Geographic Placebo Test of Impact of Increased Cell Phone Coverage on Total Attacks – District/Month

Dependent Variable:	(1) SIGACT /100,000	(2) SIGACT /100,000	(3) SIGACT /100,000	(4) FD of SIG /100,000	(5) FD of SIG /100,000	(6) FD of SIG /100,000	(7) FD of SIG /100,000	(8) FD of SIG /100,000	(9) FD of SIG /100,000	(10) FD of SIG /100,000
Spatial Lag of New Towers in *t* -1	-11.51**	-6.243**	-5.867***							
	(4.80)	(3.04)	(2.02)							
Lagged FD of Tower Count in Neighboring Districts				-0.158	-0.185	-0.217	-0.285	-0.126	-0.106	-0.236
				(0.14)	(0.19)	(0.25)	(0.34)	(0.16)	(0.16)	(0.42)
Existing Tower Count		-0.750***	-0.607**							
		(0.23)	(0.29)							
Sunni Proportion	445.4**	463.0**	412.6***							
	(207)	(211)	(112)							
Shia Proportion	40.39	56.57	-344.4***							
	(69.5)	(73.3)	(89.1)							
Observations	3717	3717	3717	3654	3654	3654	3654	3654	3654	3654
R-squared	0.25	0.26	0.32	0.01	0.02	0.12	0.12	0.04	0.07	0.07
Time FE	Half	Half	Half	Half	Quarter	Month	Month	Sect X Half	Sect X Quarter	Province X Quarter
Space FE	No	No	Province	No	No	No	District	No	No	No
First Differences	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain Iraq operated during period under study. Robust standard errors, clustered at the district level in parentheses. Each model's fixed effects are noted. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007).

Table A6. Impact of Increased Cell Phone Coverage on Total Attacks controlling for Past Sectarian Violence – District/Month

Dependent Variable: First Differences in SIGACTs/100,000	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A: Core Specifications		*Panel B: Controls for Total Sectarian Violence*			*Panel B: Controls for Targeted Killings by Sectarian Militias*		
Lagged FD of Towers	-0.116**	-0.151**	-0.143**	-0.137*	-0.166**	-0.146**	-0.144**	-0.167**
	(0.056)	(0.070)	(0.070)	(0.069)	(0.072)	(0.071)	(0.071)	(0.073)
FD of Sectarian Violence	0.0259	0.0260	0.00946	-0.0392		0.0273	-0.0307	
	(0.031)	(0.031)	(0.048)	(0.051)		(0.045)	(0.061)	
Lagged FD of Sectarian Violence			-0.0347	-0.112		0.00724	-0.0797	
			(0.047)	(0.072)		(0.055)	(0.098)	
Second Lag FD of Sectarian Violence				-0.114			-0.117	
				(0.069)			(0.084)	
Sectarian Violence 3-Month Lagged Moving Average Lag					-0.143**			-0.209
					(0.066)			(0.15)
Observations	3717	3717	3717	3654	3654	3654	3654	3654
R-squared	0.28	0.28	0.31	0.01	0.01	0.03	0.06	0.07
Time FE	Month	Month	Month	Month	Month	Month	Month	Month
Space FE	No	District	District	District	District	District	District	District
Sectarian FE	Yes	Yes	2 Lags	3 Lags	Lagged Moving Avg.	2 Lags	3 Lags	Lagged Moving Avg.
First Differences	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain Iraq operated during period under study. Robust standard errors, clustered at the district level in parentheses. Each model's fixed effects are noted. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007).

Table A7. Impact of Increased Cell Phone Coverage by Attack Type with Slope Shifts

Dependent Variable: FD of Attacks/100,000	(1) All Attacks	(2) Direct Fire	(3) Indirect Fire	(4) Total IED Attempts	(5) IEDs Cleared / Total Attempts
Lagged FD of Towers (pre-Aug. '06)	-0.193**	-0.053*	0.0096	-0.133*	
	(0.088)	(0.032)	(0.006)	(0.064)	
Lagged FD of Towers (Aug. '06 – June '07)	-1.248**	-0.469*	-0.0235	-0.523	0.0084
	(0.56)	(0.25)	(0.031)	(0.33)	(0.007)
Lagged FD of Towers (post-June '07)	0.145	0.025	0.0045	0.209*	-0.0042
	(0.21)	(0.08)	(0.024)	(0.12)	(0.005)
Observations	3654	3654	3654	3654	1701
R-squared	0.11	0.05	0.12	0.08	0.02

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain operated during period under study. Robust standard errors, clustered at the period-district level in parentheses. All results include period-district and month fixed effects. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007). Column (5) calculated only for period after September 2006 when data distinguish successful and failed IED attacks.

Table A8. Impact of Increased Cell Phone Coverage by Attack Type and Sect

Dependent Variable: Attacks/100,000	(1) All Attacks	(2) Direct Fire	(3) Indirect Attacks	(4) IED Attempts	(5) IEDs Cleared / Total Attempts
Panel A: Mixed Areas					
Tower First Differences	-0.251	-0.0836	-0.0007	-0.133	0.0096
	(0.19)	(0.077)	(0.0068)	(0.091)	(0.011)
Observations	580	580	580	580	580
R-squared	0.30	0.24	0.35	0.25	0.10
Panel B: Kurdish/Shia Areas					
Tower First Differences	-0.00960	-0.00668	0.00144	0.0237	-0.0010
	(0.058)	(0.027)	(0.0074)	(0.020)	(0.005)
Observations	2436	2436	2436	2436	1134
R-squared	0.10	0.08	0.10	0.04	0.04
Panel C: Sunni Areas					
Tower First Differences	-2.259*	-0.877**	0.133	-1.048	-0.0612
	(1.07)	(0.39)	(0.13)	(0.71)	(0.034)
Observations	638	638	638	638	297
R-squared	0.23	0.10	0.21	0.21	0.12
Panel D: Mixed and Sunni Areas Combined					
Tower First Differences	-0.496	-0.158	0.0130	-0.315*	-0.0035
	(0.29)	(0.12)	(0.015)	(0.16)	(0.012)
Observations	1218	1218	1218	1218	567
R-squared	0.18	0.08	0.16	0.15	0.04

Notes: Unit of analysis for violence is district/month, February '04 – January '09. Analysis restricted to 63 districts in which Zain operated during period under study. Robust standard errors, clustered at the district level in parentheses. All results include month and district fixed effects. Estimates which are significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data and WFP surveys (2003, 2005, and 2007). Sectarian areas coded as Kurdish/Shia or Sunni if greater than 60% of population is from that affiliation, mixed otherwise. Column (5) calculated only for period after September 2006 when data distinguish successful and failed IED attacks.

Table A9: Summary Statistics – Tower Areas, 15-day periods

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Panel A: Violence Variables – Full Sample					
SIGACTs	29,744	8.94	15.20	0	224
Attacks	29,744	3.60	7.15	0	127
Direct Fire	29,744	0.40	1.89	0	50
IEDs	29,744	4.09	7.39	0	127
Panel B: Tower Areas Characteristics – Full Sample					
Area (km^2)	1,859	87	118.	50	449
Proportion New	1,859	0.13	0.28	0	1
Population	1,859	354,041	308,394	0	1,445,185
Proportion Urban	1,859	0.92	0.27	0	1
Proportion Sunni	1,859	0.22	0.26	0	1
Proportion Shia	1,859	0.78	0.26	0	1
Panel C: Violence Variables – Less than 50% New					
SIGACTs	26,368	9.87	15.77	0	224
Attacks	26,368	4.00	7.46	0	127
Direct Fire	26,368	0.44	1.99	0	50
IEDs	26,368	4.50	7.68	0	127
Panel D: Tower Areas Characteristics – Less than 50% New					
Area (km^2)	1,648	67.40	81.69	49.9	449
Proportion New	1,648	0.03	0.08	0	0.49
Population	1,648	394,371	303,913	3,770	1,445,185
Proportion Urban	1,648	0.97	0.18	0	1
Proportion Sunni	1,648	0.21	0.24	0	1
Proportion Shia	1,648	0.78	0.24	0	1
Panel E: Violence Variables – More than 50% New					
SIGACTs	3,376	1.67	5.75	0	78
Attacks	3,376	0.52	2.14	0	33
Direct Fire	3,376	0.12	0.76	0	17
IEDs	3,376	0.89	3.04	0	42
Panel F: Tower Areas Characteristics – More than 50% New					
Area (km^2)	211	254.5	200.2	49.9	449
Proportion New	211	0.87	0.16	0.50	1
Population	211	39,046	67,991	0	496943.00
Proportion Urban	211	0.55	0.50	0	1
Proportion Sunni	211	0.25	0.37	0	1
Proportion Shia	211	0.74	0.38	0	1

Notes: Unit of analysis for violence is tower/bimonth (15-day period). Tower coverage areas created by a 4km radius around cell phone towers in urban areas and 12km radius in rural areas. Violent events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008) gridded population data. Includes only towers with at least 8 periods before and after onair date.

Table A10. Impact of Increased Cell Phone Coverage by Attack Type and Period

Dependent Variable:	(1) All Attacks	(2) Direct Fire	(3) Indirect Fire	(4) Total IED Attempts
Panel A: Excluding towers built 8/06 to 7/07				
Post	-0.685***	-0.408***	-0.0932**	-0.176*
	(0.21)	(0.11)	(0.040)	(0.098)
*Post*New*	-0.545*	-0.0765	0.147**	-0.475***
	(0.32)	(0.17)	(0.060)	(0.14)
Observations	22144	22144	22144	22144
R-squared	0.71	0.61	0.34	0.76
Panel B: Dropping 2008				
Post	-0.379**	-0.275***	-0.0561	-0.164*
	(0.18)	(0.097)	(0.043)	(0.088)
*Post*New*	-0.696*	-0.181	0.0926*	-0.293**
	(0.36)	(0.19)	(0.053)	(0.13)
Observations	28208	28208	28208	28208
R-squared	0.79	0.69	0.31	0.82

Notes: Unit of analysis is tower areas for 15-day periods in relative time from tower onair date. Coverage areas created by a 4km radius around cell phone towers in urban areas and 12km radius in rural areas. New towers are those whose catchment is at least 20% new coverage. Robust standard errors, clustered at the tower level in parentheses. All specifications include tower and quarter fixed effects. Estimates significant at the 0.05 (0.10, 0.01) level are marked with at ** (*, ***). Violent Events based on data on MNF-I SIGACT-III database. Cell tower data provided by Zain Iraq. Population data from LandScan (2008).